Colette PAUPARDIN*†, Claude LEDDET** & Roger GAUTHERET***:

Histo-chemical investigations on Fennel. Physiological connection between terpen's nature and histological structure of secretory apparatus (3)****

C. ポーパルダン*†・C. ルデ**・R. ゴートレ***:

ウイキョウの組織化学的研究. テルペン類と分泌器官の組織学的・生理学的関連 (3)****

D—Comparative intensity of cell secretion

The estimation of gross secretion has shown that, in regard to the total essential oil content, organs can be classified as follows, in decreasing order: fruit, second-class inflorescential peduncle, leaf lamina, primary class inflorescential peduncle, root, stem. Now, this classification gives no indication on the secretory activity level, referred to one cell for each organ. A significant estimation requires to consider the relative importance of secretory and ordinary cells. This relative importance is indicated in Tab. 6 and 7. It can be seen that, on organ sections, the relative surface occupied by secretory cells differ according to organs.

The ratio surface occupied by canal cells/ordinary cells reach a maximal value for fruit, followed by second-class inflorescential peduncle. Knowing this ratio and the anethol content of one organ (Tab. 6 and 7), it is possible to calculate the relative activity, referred to one cell for each organ (Tab. 6 and 7). The results of the calculation are surprising in the case of bitter fennel. The relative secretion of t-anethol, referred to one secretory cell reaches the maximal value for the leaf lamina. In this case, the relative secretory activity of cell lamina is twice more important than for the fruit secretory cell. Similar estimations were realized for other components of the bitter fennel's essential oil. Results are summarized in Tab. 8.

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Tab. 6. Secretory power of secretory cells belonging to the principal aerial organs of bitter fennel.

Organ	Ratio canals surface / ordinary cells surface on transverse sections	Anethol concentration μg/g (fresh tissue)	Relative value of secretory activity referred to one secretory cell
Petiole	1.3%	170	1
Leaf lamina	1.4%	1864	10.2
Primary class inflorescential peduncle	1.1%	1034	7.2
Second-class inflorescential peduncle	2.9%	1788	4.7
Fruit	5.2%	3419	5

Tab. 7. Secretory power of secretory cells belonging to the principal aerial organs of sweet fennel.

Organ	Ratio canals surface / ordinary cells surface on transverse sections	Anethol concentration μg/g (fresh tissue)	Relative value of secretory activity referred to one secretory cell
Petiole	1.4%	327	1
Leaf lamina	2.2%	690	1.3
Pirmary-class inflorescential peduncle	2%	943	2
Second-class inflorescential peduncle	3%	2863	4
Fruit	4.9%	7468	6.5

Discussion The comparison of chemical and histological data, concerning the secretory system of fennel, has thrown into relief some remarks, which will now be discussed.

First of all, we have established the existence of important variations of essential oil's composition according to organs. T-anethol is the main component

Tab. 8. Relative value of secretory activity for principal components (except anethol) of bitter fennel essential oil. The results refer to one secretory cell and are expressed in arbitrary units.

Organs	α-pinene	limonene	myrcene	fenchone	estragol	anisaldehyde
Stem	—	0.2	0.2	—	—	—
Petiole	—	0.3	—	—	—	0.1
Leaf lamina	8.3	126	2.4	3.1	26.4	3.9
Primary-class inflorescential peduncle	0.04	0.4	—	0.2	0.04	—
Seccond-class inflorescential peduncle	2.2	0.2	—	1.5	0.3	—
Young fruit harvested 26.03.83	4.5	1.5	4.6	1.7	1.0	—
Young fruit harvested 6.07.82	5.1	5.3	0.8	2.3	1.8	—
Green fruit harvested 16.07.82	0.7	3.9	3.7	32.0	2.9	—

of essential oils, extracted from the aerial organs, whereas the principal root oil constituant is dillapiol. Small amounts of this phenylpropane have been detected in the lamina of sweet fennel, but not in the leaf of the bitter variety. Reciprocally, the root contains a very small quantity of anethol.

Another difference has been noticed by comparison of the essential oils extracted from root xylem and cortex. Xylem contains some α-pinene, which is not present in the cortex, whereas this tissue contains limonene and myrcene.

In other respects, differences concerning the various aerial organs are principally quantitative. On the whole, qualitative differences may be classified in three kinds of aromatic profiles concerning respectively aerial organs, root xylem and root cortex.

To these three patterns (this classification has been established only for Sweet Fennel) correspond three structures: 1) Root cortex contains secretory bags which are almost spherical and formed of very few cells. 2) Canals of root xylem which have a very small diameter. 3) Canals of the aerial organs show more numerous secretory cells than those of the root, and their cavity is larger specially in the case of pith canals.

To sum up, it can be said that the essential oil composition doesn't characterize an organ but a kind of secretory canal.

This specificity is very strict in the whole plant, but it may be modified by *in vitro* culture. Indeed, the callus developped at the bottom of a stem segment synthesize dillapiol and on the other hand, its secretory canals get out of shape and acquire, finally some likeness to the secretory bags of the root cortex. In addition, the composition of essential oil produced by callus cells without specific canals, is quite irregular. It is obvious that there is a connection between the nature of the secretion and the histological organisation of the secretory system. Any structural alterations of this system carry modifications of essential oil composition.

A second remark suggested by our results, concerns the discontinuity of the secretory canals. Hasty observations of transverse sections can lead to believe that the secretory system is composed of canals connected by numerous anastomosis. Then, observations of serial sections have enabled us to obtain space perception of this system. We noticed that it was composed of numerous units quite independent. On the whole, we have detected three discontinuities concerning repectively collar, branching of the stem and fruit insertion. The drastic modification of essential oil composition which appears on a very short length of the collar, may be explained by the progressive substitution of "stem type canals" by "root type canals". No anastomosis exists between these two types.

We must point out that our results can clarify an apparent opposition between Hope and Toth's observations.

Hope had detected some t-anethol in the fennel root, whereas Toth had not extracted anethol from this organ. There was really no mistake. None of these two scientists was wrong. The first has worked with bitter fennel of which the root contains some anethol; whereas Toth considered sweet fennel root, which is deprived of anethol.

Another aspect of our work concerns the secretory activity of the canal cells. Global analysis suggests that the maximal secreting activity occurs in the fruits. But taking into account the ratio secretory cells/ ordinary cells, the fruit preponderance is, reduced. And in the case of bitter Fennel, the activity of the leaf lamina secreting cells is twice this exhibited by the fruit secreting cells, at least for anethol and limonene.

Finally, some of our results can be applied to Fennel improvement. Working on the bitter variety, we remarked that plants improved by genetic methods (Deneuche), produced fruits containing more secretory canals (6 to 10) than the basic number. It is possible that this test would help in the development of an improvement program.

Most of this work was realized in Pernod-Ricard's laboratory. We must express our gratitude to Mr Patrick Ricard, president of this Society, and recall that his predecessor, Jean Hémard agreed to fundamental research being performed in his industrial factory. Mr Patrice Desmarets, director of the plant physiology department of the Pernod-Ricard Society, has kindly facilitated the development of our investigations.

Summary

Our investigations concern relations between the histological structure of fennel's secreting system and the essential oil composition. We considered Sweet and Bitter Fennel.

The essence composition fluctuates according to organs, and at the same time, canals morphology exihibits modifications. The more chemical and histological differences can be observed between the root and the aerial organs.

This suggested that the secretory system must be made of small units, which are not connected but are really independent. Serial sections have shown that secretory canals are short and independent. This was especially observed at three levels: collar, branching and the limit between fruit and peduncle. *In vitro* culture provokes important alterations concerning the essential oil composition and the secretory system structure, which may be quite different from those observed in normal plants. Gross analysis suggests that the secretory power of canal cells reaches a maximal value in fruits. But considering the ratio secreting cells/ordinary cells, the fruit preponderance is reduced.

And in the case of bitter fennel, the more active secreting cells are those of leaf lamina. The secreting activity of these cells is twice this shown by the fruit secreting cells.

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ウイキョウ (fennel) の分泌系の組織学的構造を精油組成との関係から研究を行い,

特に sweet fennel と bitter fennel について検討した。精油組成は器官に応じて変化し，同時に分泌管の形態も変化した。更に多くの化学的・組織学的な違いが根と地上部の器官との間で観察された。このことは，分泌系はつながっておらず，独立する小ユニットからなることを示唆している。連続切片は，分泌管が短くて独立していることを示した。このことは，特に三つのレベル，頸領，分枝及び果実と花柄の間の境界で，観察された。*in vitro* 培養では，正常な植物体と比べると精油組成はかなり異なり，分泌系の構造も重要な変異を示した。粗分析から，分泌管細胞の分泌力は果実において最大値に達することが示唆された。しかし，分泌細胞と通常細胞との比率を考慮すると果実の優位性は下がる。bitter fennel の場合では，より活性の高い分泌細胞は葉身の分泌細胞である。これら細胞の分泌活性は果実の分泌細胞の活性の約2倍である。

□毛藤勤治：**ユリノキという木** 301pp. 1989. アボック社，東京．￥1,800. 自然林1万7千ヘクタールを皆伐して牧野にした体験をもつ著者が，その悔いをユリノキの育苗に向け，かたわらユキノリのすべてを知ろうと，文献や現地調査を重ねた知見を披露したもの。生態，古生物，生薬学の専門家の寄稿がある。内容は化石から現世種の紹介にはじまり，形態や成分，北米での現状，日本各地の状況，植栽の方法など多方面におよぶ。一つの種類についてこんなにいろいろ書いた本はあまりないだろう。　（金井弘夫）

□ Leins, P., S. C. Tucker & P. K. Endress (ed.): **Aspect of floral development** 239pp. 1988. Gebrüder Borntraeger, Berlin. 120DM, US ＄68.80. 本書は1987年ベルリンで開かれた国際植物学会でのシンポジウム，"Floral development: Evolutionary aspects and special topics" の proceedings である。近年，走査型電子顕微鏡(SEM)の普及により，植物形態学の分野にも SEM が応用され，植物の器官の発生の様子が3次元的に明瞭に示せるようになった。花の形態は，系統を議論するのに重要な情報が多く含まれているが，がく片，花弁，おしべ，めしべ等の発生の情報も加わえることにより花の形態の理解が深まり，系統の議論の客観性が増すことが期待できる。本書では，ヤシ科，ショウガ目，サボテン科，ヒルギ科，シレンゲ科，ブドウ科，クロウメモドキ科，ゴマノハグサ科，ヒメハギ科，ナス科，マメ科，ツツジ科，パイナップル科，アオギリ科，ソテツ目等を扱った論文が掲載されている。日本からは西野栄正博士がホツツジ属の花の発生の論文をだされている。本書を見れば，現在，花の比較発生研究の分野ではどのような問題があるか理解できる。　（寺林　進）